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Clinical cases referring to diagnosis and management of patients with thoracic aortic pathologies involving the aortic arch: A companion document of the 2018 European Association for Cardio-Thoracic Surgery (EACTS) and the European Society of Vascular Surgery (ESVS) expert consensus document addressing current options and recommendations for the treatment of thoracic aortic pathologies involving the aortic arch.

[1]Martin Czerny, [2]Jürg Schmidli, [2]Luca Bertoglio, [1]Thierry Carrel, [2]Roberto Chiesa, [2]Rachel E Clough, [1]Martin Grabenwöger, [1]Fabian A Kari, [1]Carlos A Mestres, [1]Bartosz Rylski, [1]Florian Schönhoff, [1]Konstantinos Tsagakis, [2]Thomas R Wyss,

[1] Representing the European Association for Cardio-thoracic Surgery (EACTS)

[2] Representing the European Society of Vascular Surgery (ESVS)

On behalf of the writing committee for the 2018 EACTS/ESVS expert consensus document addressing current options and recommendations for the treatment of thoracic aortic pathologies involving the aortic arch.

Document reviewers:

Corresponding authors:

Martin Czerny, MD, MBA, FESC, MEBCTS, FEBVS
University Heart Center Freiburg- Bad Krozingen, Albert Ludwigs University Freiburg, Faculty of Medicine
Hugstetterstrasse 55, 79106 Freiburg, Germany, Phone +49 761 270 28180 Fax +49 761 270 25500
e-mail martin.czerny@universitaets-herzzentrum.de

Jürg Schmidli, MD, FEBVS
Department of Cardiovascular Surgery, Inselspital, Bern University Hospital, University of Bern, Switzerland
Freiburgstrasse 15, 3010 Bern, Switzerland, Phone +41 31 632 2602 Fax +41 31 632 2919
e-mail juerg.schmidli@insel.ch

Affiliations

Martin Czerny- University Heart Center Freiburg- Bad Krozingen, Freiburg, Germany
Jürg Schmidli- Department of Cardiovascular Surgery, Inselspital, Bern University Hospital, University of Bern, Switzerland
Luca Bertoglio- “Vita salute” University, Division of Vascular Surgery, Ospedale San Raffaele, Milan, Italy
Thierry Carrel- Department of Cardiovascular Surgery, Inselspital, Bern University Hospital, University of Bern, Switzerland
Roberto Chiesa- Vita salute” University, Division of Vascular Surgery, Ospedale San Raffaele, Milan, Italy
Rachel E Clough- Division of Imaging Sciences and Biomedical Engineering, St Thomas’ Hospital, King’s College London, London SE1 7EH
Martin Grabenwöger, Heart Center Hiertzing, Vienna, Austria
Fabian A Kari- University Heart Center Freiburg- Bad Krozingen, Freiburg, Germany
Carlos A Mestres- University Clinic for Cardiovascular Surgery, University Hospital Zurich, Zurich, Switzerland
Bartosz Rylski- University Heart Center Freiburg- Bad Krozingen, Freiburg, Germany
Florian Schönhoff- Department of Cardiovascular Surgery, Inselspital, Bern University Hospital, University of Bern, Switzerland
Konstantinos Tsagakis- West German Heart Center, Essen, Germany
Thomas R Wyss- Department of Cardiovascular Surgery, Inselspital, Bern University Hospital, University of Bern, Switzerland

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Luca Bertoglio: Consultant for Cook Medical, Travel grants, speaking fees with Cook Medical, Gore, Jotec, Medtronic, Cordis

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Bartosz Rylski: Consultant for Terumo Aortic

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Case 1- Aortic arch aneurysm

Clinical scenario. A 73-years-old male undergoes annual computed tomography angiography (CTA) surveillance of an atherosclerotic aortic arch aneurysm which was detected by change during a chest X-ray having been performed for unspecific pain 5 years ago. Within the last year, a diameter increase of 6mm with now a maximum diameter of 57mm was detected. The patient is clinically asymptomatic. Due to size and progression, therapy is recommended.

Additional examinations guiding how to proceed. The patient undergoes a full cardiovascular workup including a new electrocardiogram (ECG)-triggered CTA starting cranially including the circle of Willis and extending below to the level of the femoral heads. Furthermore, coronary angiography, a trans-thoracic echocardiogram (TEE) as well as duplex scanning of the supraaortic branches is done.

Constellations favoring open aortic arch replacement. The aortic arch aneurysm is accompanied by proximal ascending aortic dilatation up to 47 mm in the mid-ascending aorta and 55 mm at the level of the offspring of the brachiocephalic trunk. At the transition between zone 2 and zone 3, the diameter is 38 mm.

Arch morphology is a type III aortic arch and the distance between the sternal notch and the left subclavian artery (LSA) is 5cm which should enable a sufficient exposure of the entire aortic arch pathology by median sternotomy. The maximum diameter of the aortic root is 38 mm. There is a moderate but heavy calcified aortic valve stenosis and a 90% complex stenosis of the left anterior descending coronary artery (LAD). Biventricular function is normal and the remaining valvular status shows morphologically and functionally regular findings. The supraaortic vessels are free from hemodynamically significant lesions.

Treatment plan. The patient is recommended to undergo an open ascending and aortic arch replacement, a left internal mammary artery bypass to the LAD. Finally, aortic valve replacement with a biological prosthesis is done. The aortic arch will be replaced with a branched graft to eliminate the largest possible amount of native diseased aortic arch tissue and to reduce the risk of any kind of suture aneurysm by a trade-off in leaving native aortic arch tissue in place.

Constellations favoring open arch replacement using the frozen elephant trunk (FET) technique. CTA shows that zone 3 is still diseased with a maximum diameter of 55mm and regular diameters are reached again in proximal zone 4. The aortic root diameter is 37 mm, the mid-ascending diameter is 45 mm. The valvular status is regular and there is no coronary heart disease.

Treatment plan. The patient is recommended to undergo total aortic arch replacement using the FET technique including supracoronary replacement of the ascending aorta. The descending anastomosis of the FET prosthesis cuff (at the transition between the surgical prosthesis and stent-graft portion) can be performed proximal in the aortic arch in zone 2 to reduce the risk of the left laryngeal nerve palsy and to have better exposure due to the gained proximity which also easens hemostasis. The stent-graft portion of FET prosthesis should be either chosen to be able to treat the entire pathology in one step or- if any kind of doubt regarding elevated risk of the occurrence of symptomatic spinal cord injury arises- should be chosen short with secondary distal thoracic endovascular aortic repair (TEVAR) extension. Intraoperative aortoscopy during hypothermic circulatory arrest is not mandatory, however may be very helpful to control the distal landing zone and the stent-graft portion deployment process.

Constellations favoring hybrid aortic arch replacement. The ascending aortic diameter is 37mm and the aortic arch aneurysm starts in zone 2 extending to the transition of zone 4 to zone 5. Revascularization of both the left common carotid artery (LCCA) and the LSA would provide a 2.5 cm long proximal landing zone.

Treatment plan. The patient is recommended to undergo a double transposition of supraaortic vessels via upper median hemi-sternotomy. This operation includes transposition of the LCCA into the brachiocephalic trunk followed by transposition of the LSA into the already transposed LCCA. In case of isolated off-spring of the left vertebral artery from the aortic arch, it can be re-implanted to the LCCA or LSA with or without (depending on the local anatomical situation) with an interposition of the great saphenous vein. Due to the extent to the transition of zone 4 to zone 5, a CSF drainage is inserted prior to the procedure for spinal cord protection.

Constellations favoring branched endovascular aortic arch repair. The patient has regular ascending aortic dimensions without any signs of atherosclerotic affection. The pathology ends at the transition between zone 3 and zone 4. CTA shows that the distance between the brachiocephalic trunk and the LSA is short and double transposition might provide a proximal landing zone of only 1.5 cm in zone 1. There is no coronary heart disease and the valvular status is normal, however the left ventricular ejection fraction is severely reduced to 25%. The anatomy of the aortic arch including supraaortic vessel diameter is suitable for implantation of a double branched endo-graft, distal access vessels are suitable for retrograde delivery of the main portion of the stent-graft and proximal access vessels are suitable for bridging stent-grafts into the brachiocephalic trunk and into the LCCA. As commercially available prostheses do have two branches, the LSA needs revascularization either in advance or-preferably to avoid a second opening of the incision, simultaneously.

Treatment plan. The patient is recommended to undergo LSA to LCCA bypass on the left side and implantation of a double branched endo-graft via the femoral artery. As the distal landing zone of the stent-graft component is at the transition between zone 3 and zone 4, CSF drainage is not deemed necessary for additional spinal cord protection.

Case 2- Descending aortic aneurysm involving the distal aortic arch

Clinical scenario. A 77- year old male presents with 65mm thoracic aortic aneurysm starting immediately distal to the LSA origin in zone 3. Five centimeter cranial to the celiac trunk in zone 5, the diameter becomes regular again. The diagnosis was made by chance as the patient had a chest x-ray prior to an urological procedure.

Additional examinations guiding how to proceed. The patient undergoes a full cardiovascular workup including a new ECG triggered CTA starting cranially including the circle of Willis and extending below to the level of the femoral heads. Furthermore, coronary angiography, a trans-thoracic echocardiogram (TEE) as well as duplex scanning of the supraaortic branches is done.

Constellations favoring a limited combined vascular and endovascular procedure. Coronary angiography reveals regular findings. Echocardiography shows a good biventricular function, a morphologic and functional regular valvular status, the supraaortic vessels are free from hemodynamically relevant lesions. The proximal landing zone without any kind of transposition is 8mm from the distal end of the LSA offspring to the begin of the lesion measured on the inner curvature of the aortic arch. Diameters of the ascending aorta and the aortic arch at the level of the intended proximal landing zone are 3.8cm and 3.6cm respectively. LSA to LCCA bypass/ transposition would provide a proximal landing zone of 2.5cm. Access vessels for retrograde delivery do have a sufficient size and morphology.

Treatment plan. The patient is recommended to undergo LSA to LCCA bypass/ transposition with simultaneous TEVAR. A CSF drainage is inserted prior to the procedure for spinal cord protection.

Constellations favoring a more extensive combined vascular and endovascular procedure. Coronary angiography reveals regular findings. Echocardiography shows a good biventricular function, a morphologic and functional regular valvular status, the supraaortic vessels are free from hemodynamically relevant lesions. Diameters of the ascending aorta and the aortic arch at the level of the intended proximal landing zone are 3.8cm and 3.6cm respectively. The proximal landing zone without any kind of transposition is 8mm from the distal end of the LSA offspring to the begin of the lesion measured on the inner curvature of the aortic arch but LSA to LCCA transposition would merely extend the proximal landing zone to 14mm. Additionally, the patient has an isolated offspring of the left vertebral artery. A more extensive form of transposition (double transposition- in this case actually triple transposition due to the isolated left vertebral artery offspring) would extend the proximal landing zone to 2.7cm. Access vessels for retrograde delivery do have a sufficient size and morphology.

Treatment plan. The patient is recommended to undergo double transposition (LCCA to brachiocephalic trunk and LSA to LCCA transposition with additional transposition of the left vertebral artery) with simultaneous TEVAR from zone 1 to zone 5. A CSF drainage is inserted prior to the procedure for spinal cord protection.

Constellations favoring a total endovascular approach. Coronary angiography reveals 2-vessel disease with lesions being good targets for percutaneoud coronary intervention (PCI). Echocardiography shows a severely reduced left ventricular function, the valvular status is morphologically and functionally regular, the supraaortic vessels are free from hemodynamically relevant lesions. The proximal landing zone without any kind of transposition is 8mm from the distal end of the LSA offspring to the begin of the lesion measured on the inner curvature of the aortic arch. Diameters of the ascending aorta and the aortic arch at the level of the intended proximal landing zone are 3.8cm and 3.6cm respectively. Neither LSA to LCCA nor double transposition would create a sufficient proximal landing zone, but due to the regular ascending aortic diameters, total endovascular aortic arch repair (together with LSA revascularization) is possible. Access vessels for retrograde delivery do have a sufficient size and morphology.

Treatment plan. Due to new onset of symptoms (hoarseness due to left laryngeal nerve palsy) a certain kind of time pressure to accomplish treatment arose. The initial plan to perform PCI and to wait until the time frame for dual antiplatelet therapy is too risky (CSF drainage insertion requires refraining from any kind of antiaggregatory therapy to avoid bleeding complications during insertion). The patient undergoes simultaneous LSA to LCCA revascularization and branched endovascular aortic arch repair with distal TEVAR extension to exclude the entire lesion from zone 0 down to zone 5. On day 2, CSF drainage was removed and on day 7, 2 vessel PCI was successfully performed.

Constellations favoring open surgery using the FET approach with secondary distal TEVAR extension. Coronary angiography reveals 3-vessel disease with lesions being suboptimal targets for PCI. Echocardiography shows a regular biventricular function but hemodynamically significant aortic stenosis with a calcific distribution pattern being suboptimal for transcatheter aortic valve implantation (TAVI). The proximal landing zone without any kind of transposition is 8mm from the distal end of the LSA offspring to the begin of the lesion measured on the inner curvature of the aortic arch. Neither LSA to LCCA nor double transposition would create a sufficient proximal landing zone, the diameter of the ascending aorta is 4.5cm, which obviates total aortic arch debranching as to the high risk of retrograde type A aortic dissection. Access vessels for secondary retrograde delivery do have a sufficient size and morphology.

Treatment plan. The patient is recommended to undero triple CABG (LIMA-LAD, saphenous vein grafts to CX and RCA- total arterial revascularization is not preferred as to the potential need for vasopressors after total aortic arch replacement and the risk for vasospasm-, biological aortic valve replacement and aortic arch replacement using the FET technique with a short stent-graft component ending in the proximal zone 4. After a recovery phase of 6 weeks, the patient undergoes TEVAR extension down to zone 5 having had CSF drainage insertion in advance after temporary withdrawal of antiaggregatory therapy.

Case 3- Remaining dissection after type A repair

Clinical scenario. A 76 year-old male patient presents with a 67mm proximal descending aortic aneurysm on the basis of a remaining dissection 5 years after type A repair. At that time, the patient received a supracoronary ascending aortic replacement with a 28mm tube graft. At index surgery, hemiarch replacement was performed. The patient was lost to follow-up due to a change of residence and now had a chest X-ray due to planned orthopedic surgery showing a large mediastinal mass. Secondarily, a non-ECG triggered thoracic CTA was performed establishing the diagnosis. The mechanism for aneurysm formation is thought to be a large communication between the true and the false lumen in zone 2 functionally acting as a new primary entry tear enhancing continuing growth.

Additional examinations guiding the decision how to proceed. The patient undergoes a full cardiovascular workup including a new ECG triggered CTA starting cranially including the circle of Willis and extending below to the level of the femoral heads. Furthermore, coronary angiography, a trans-thoracic echocardiogram (TEE) as well as duplex scanning of the supraaortic branches is done.

Constellations favoring open surgery using the FET technique. CTA shows remaining dissection of all three supra aortic vessels. The descending aorta reaches a regular size at the transition between zones 4 and 5, the size of the true lumen is 32x20mm, there are no communications between the lumina at the thoracic level, the celiac trunk, the superior mesenteric artery and the right renal artery originate from the true lumen, the left renal artery originates from the false lumen with a communication between lumina at that level. TTE shows good biventricular function but moderate aortic regurgitation with a vena contracta of 4mm based on a remaining/recurring prolapse of the non/right coronary commissure. The remaining valvular status is morphologically and functionally normal. Coronary angiography and duplex scanning of the supraaortic branches show regular findings.

Treatment plan. The patient is recommended to undergo total aortic arch replacement using the FET technique using the short stent-graft component for spinal cord protection extending into the transition between zones 3 and 4 with the potential to induce complete remodeling of the entire thoracic aorta simultaneously with biological aortic valve replacement to fix the aortic regurgitation component. In case of need of distal extension, secondary TEVAR can be performed at a later stage according to the completion CTA findings. The left renal artery originating from the false lumen is not at risk after thoracic false lumen thrombosis as the communication between both lumina will provide continuing blood supply across the membrane.

Constellations favoring classical ET implantation. CTA shows remaining dissection of all three supra aortic vessels. The descending aorta reaches a regular size at the transition between zones 4 and 5 However, the true lumen shows a pseudocoarctation-like narrowing at the level of zone 4. The celiac trunk, the superior mesenteric artery and the right renal artery originate from the true lumen, the left renal artery originates from the false lumen with a communication between lumina at that level.

Treatment plan. True lumen FET implantation is highly likely to induce immediate lower body malperfusion. Therefore a two-step approach to fix the entire disease process is needed. The patient is recommended to undergo total aortic arch replacement using the classical ET technique with excision of the dissection membrane during lower body hypothermic circulatory arrest as distal as possible to maintain regular distal perfusion and to be able to access the ET component in zone 4 at the second stage. After recovery, distal open surgical extension to zone 5 is done.

Constellations favoring transposition of supraaortic vessels and TEVAR. CTA shows no remaining dissection of the supraaortic vessels, the aortic arch is free from remaining dissection up to zone 2. The descending aorta reaches a regular size at the transition between zones 4 and 5, the size of the true lumen is 32x20mm, there are no communications between the lumina at the thoracic level, the celiac trunk, the superior mesenteric artery and the right renal artery originate from the true lumen, the left renal artery originates from the false lumen with a communication between lumina at that level. Subclavian-to-carotid bypass/ transposition would create a 2.5cm landing zone for TEVAR. The CTA showed an interrupted circle of Willis with the rare constellation of a stand-alone left vertebral artery supplying the entire posterior circulation with no posterior communicant arteries.

Treatment plan. The patient is recommended to undergo LSA to LCCA bypass (as transposition needs longer clamping times creating unnecessary risk in this stand-alone left vertebral artery constellation) with TEVAR extending into zone 5 where aortic diameters are regular. The procedure is performed using a CSF drainage for spinal cord protection. The left renal artery originating from the false lumen is not at risk after thoracic false lumen thrombosis as the communication between both lumina will provide continuing blood supply across the membrane.

Constellations favoring total endovascular aortic arch repair: CTA shows that the indwelling ascending aortic prosthesis has a sufficient length of 8cm, there is no remaining dissection of the supraaortic branches. The left common carotid artery has a diameter of 8mm. The descending aorta reaches a regular size at the transition between zones 4 and 5, the size of the true lumen is 32x20mm, there are no communications between the lumina at the thoracic level, the celiac trunk, the superior mesenteric artery and the right renal artery originate from the true lumen, the left renal artery originates from the false lumen with a communication between lumina at that level. Regarding the proximal landing zone, neither subclavian-to-carotid bypass/ transposition or even double transposition would gain a sufficient landing zone length. The valvular status is regular. However, left ventricular ejection fraction is severely reduced and the patient has poor pulmonary function.

Treatment plan. A total endovascular approach is recommended due to an ideal proximal landing zone consisting of a long straight ascending graft and due to a sufficiently large left common carotid artery for placement of the supraaortic extension (vessels smaller then 7mm are not recommend as the risk for graft occlusion is high). Simultaneous subclavian-to-carotid bypass grafting for maintaining posterior cerebellar circulation and for maintaining inflow to the spinal cord is performed. Additionally, distal TEVAR extension into zone 5 should be considered. The procedure is performed using a CSF drainage for spinal cord protection. The left renal artery originating from the false lumen is not at risk after thoracic false lumen thrombosis as the communication between both lumina will provide continuing blood supply across the membrane

Case 4- Type B aortic dissection

Clinical scenario. A 58-year-old male patient with a chronic type B aortic dissection is presented at the outpatient clinic for an expert opinion. For six years, the type B dissection is asymptomatic under best medical treatment. The patient reports no physical restrictions. The ECG triggered CTA confirms the location of the primary entry tear immediately distal to the LSA offpsring. The dissection extends downstream along the entire thoracoabdominal aorta and ends in zone 10. Both visceral arteries and the right renal artery arise from the true lumen beside the left renal artery, which is perfused from both the true and the false lumen. All thoracic segmental arteries arteries arise from the false lumen. The diameter of the proximal descending aorta is 58mm and demonstrates progression of 8mm within the last year.

Additional examinations guiding the decision how to proceed. The patient undergoes a full cardiovascular workup including a new ECG triggered CTA starting cranially including the circle of Willis and extending below to the level of the femoral heads. Furthermore, coronary angiography, a trans-thoracic echocardiogram (TEE) as well as duplex scanning of the supraaortic branches is done.

Constellations favoring a combined vascular and endovascular approach. The true lumen in CTA is in Zone 4 and 5 not collapsed. Multiplanar reformation of the thoracic aorta from 1.5mm CTA slices demonstrates:

- Diameter of the ascending aorta 40mm.
- Diameter in Zone 2 35mm.
- Sealing zone between the distal rim of left carotid artery orifice and the entry tear 23mm.
- Diameter of the entire aorta in Zone 4 and 5 42mm.
- Maximal and minimal diameter of the true lumen in Zone 4 and 5 28x11mm, respectively.

The diameter of left common carotid artery is 8mm. In CTA and carotid artery ultrasound nor calcification either stenosis is observed in left common carotid artery. In cerebral CTA, the Willis circle is complete.

Treatment Plan. A two-staged approach is recommended: First subclavian-to-left carotid artery bypass followed by TEVAR starting in zone 2 extending into zone 5 is planned. Occlusion of the subclavian artery origin proximal to vertebral artery will be performed during the first surgical procedure or endovascular during the second procedure. Due to the perfusion of all intercostal arteries from the false lumen and the risk of spinal cord injury stent-graft deployment above the level TH8 will be planed. Extension of the treatment downstream will follow thereafter, if remodeling will be insufficient. Prior to TEVAR, the patient receives a cerebrospinal fluid drainage for spinal protection.

Constellation favoring open surgery FET. CTA shows the true lumen in Zone 4 and 5 not collapsed. The maximum diameter of the potential proximal landing zone in zone 2 is greater than 40mm and the potential length is less than 20mm. Another constellation could be concomitant aneurysm of the ascending aorta more than 50mm extending into the arch.

Treatment Plan. A frozen elephant trunk procedure is planned. CSF drainage is not routinely required but should be considered according to the intended length of the TEVAR component of the FET prosthesis. The basic strategy should be closure of the primary entry tear and according to the consecutive extent of remodeling, secondary TEVAR to extend into the distal zone 5 if needed.

Constellation favoring open distal arch and descending aortic repair. The true lumen in CTA in Zone 4 and 5 is collapsed. Two channels of false lumen are embracing the true lumen in the middle. The diameter of the aortic arch is 35mm.

Treatment Plan. Open surgical repair of the distal arch and the descending aorta via a left posterolateral thoracotomy is considered. Monitoring of cerebrospinal fluid pressure and somatosensory and motor evoked potentials will be planned intraoperatively. A left-heart or partial bypass will be used to avoid hypothermic circulatory arrest.

Case 5- Non-A-non-B aortic dissection

Clinical scenario. A 65-year-old male is admitted to the emergency departement because of acute and severe chest pain and compensated ischemia of the left leg. The patient presents with uncontrolled hypertension. The ECG triggered CTA shows a non-- non-B aortic dissection extending into the aortic arch with the descending aortic true lumen collapse. The patient presents a normal neurological status.

Additional findings guiding the decision how to proceed. The patient undergoes a full cardiovascular workup including a new ECG triggered CTA starting cranially including the circle of Willis and extending below to the level of the femoral heads. Furthermore, coronary angiography, a trans-thoracic echocardiogram (TEE) as well as duplex scanning of the supraaortic branches is done.

Constellations favoring open surgery using the FET technique. CTA shows entry in the aortic arch at the outer curvature between the left common carotid and the left subclavian artery. Dissection is extending in the arch up to the distal edge of the brachiocephalic trunk and into the left carotid artery. The maximum diameter of the ascending aorta is 47 mm. In the trans-thoracic echocardiogram moderate aortic valve regurgitation is observed. The remaining valvular status is normal. The biventricular function is good.

Treatment plan. The patient is recommended to undergo total aortic arch replacement using the FET technique including replacement of the ascending aorta and biological aortic valve replacement. The anastomosis of the FET prosthesis cuff (at the transition between the surgical prosthesis and stentgraft portion) can be performed in zone 2 to reduce the risk of recurrent nerve injury. The stent-graft portion length of FET prosthesis should be short (the intention is to close the primary entry tear) to reduce the remaining risk of symptomatic spinal cord injury to a minimum. Since the entry is close to the left subclavian artery, the short stent-graft portion will still allow closure of the primary entry tear, effective redirection blood flow into the true lumen, true lumen expansion, most probably eliminating lower extremity malperfusion and in the mid-term follow-up remodeling of the thoracic aorta.

Constellations favoring transposition of supraaortic vessels and TEVAR. CTA shows no dissection of supraaortic vessels and the entry is 2 cm distal to the left subclavian artery. There is a retrograde intramural haematoma extending into the arch up to zone 2. Ascending aortic diameter is 38 mm and in the transthoracic echocardiography the aortic valve is morphological and functional normal. Subclavian-to-carotid bypass/transposition would provide a 3.5 cm TEVAR landing zone free of dissection entry.

Treatment plan. Subclavian-to-carotid bypass/ transposition and TEVAR zone 2 are recommended to the patient. Since the ascending aorta is normal, the risk of retrograde dissection is low and TEVAR using a 3.5 cm free of entry landing zone will redirect the blood-flow into the true lumen, close the primary entry tear and most probably eliminate lower extremity malperfusion.

Case 6- Aortic arch intramural hematoma (IMH)

Clinical scenario. A 72-year-old woman with a history of hypertension, smoking, and diabetes presents with acute onset of piercing chest pain. Upon examination she has high blood pressure (210/100 mmHg). Emergency computed tomography angiography reveals an intramural hematoma extending from zone 2 to zone 5. There is no visible intimal disruption or penetrating aortic ulcer-like projection. The maximum diameter of the IMH is 4.5 cm and of the proximal descending aorta 3.0 cm.

Additional findings guiding how to proceed. Strict blood pressure and pain management was initiated immediately, which quickly rendered the patient symptomless. After 7 days, the patient was discharged home after having had a completion CTA with stable findings and was scheduled for a follow-up visit 3 months later.

Treatment plan. Best medical treatment.

Outpatient examination after 3 months. At 3-month follow-up, the patient reports an uneventful clinical course. Computed tomography angiography shows a maximum diameter of the distal aortic arch at the transition of zone 2 to zone 3 of 5.5 cm with a 1.2cm hematoma component and additionally the primary entry tear has demasked in zone 2 immediately opposite the LSA offspring. The descending thoracic aorta remains unchanged. Formally, rapid expansion has occurred and the diameter threshold of 5.5cm has been reached.

Additional findings guiding the decision how to proceed. The patient undergoes a full cardiovascular workup including a new ECG triggered CTA starting cranially including the circle of Willis and extending below to the level of the femoral heads. Furthermore, coronary angiography, a trans-thoracic echocardiogram (TEE) as well as duplex scanning of the supraaortic branches is done.

Constellations favoring a combined vascular and endovascular procedure. Despite IMH the extension into zone 2, LSA to LCCA bypass creates a 2.5cm from the primary entry tear to the distal LCCA offspring and thereby a sufficient proximal landing zone for TEVAR. Ascending aortic diameter is 36mm and aortic arch diameter at the level of the proximal landing zone ins 34mm. Access vessel diameter for retrograde delivery is 8mm and therefore adequate. Biventricular function is good, the valvular status is morphologically and functionally normal, the coronary angiogram shows regular findings and the supraaortic vessels are free from hemodynamically relevant lesions.

Treatment plan. LSA to LCCA bypass/ transposition and TEVAR extending from zone 2 to zone 4 as the primary entry tear thereby is fully closed. A CSF drainage is inserted prior to the procedure for spinal cord protection.

Constellations favoring open surgery with primary use of the FET technique. CTA shows a maximum diameter of the distal aortic arch at the transition from zone 2 to zone 3 of 5.5 cm and additionally the primary entry tear has demasked in zone 2 immediately opposite the LSA offspring. The maximum diameter of the descending aorta is now 5.0cm reaching regular diameters in zone 5. From the now visible primary entry tear downstream, a classical type B dissection component has developed expending into zone 10. Echocardiography confirms normal valve function and a good biventricular function. Coronary angiography shows a significant stenosis of the right coronary artery and duplex scanning of the supraaortic branches shows regular findings. Additionally, the ascending aorta has a maximum diameter of 45mm and transposition of all three arch vessels would be needed to create a sufficient proximal landing zone for TEVAR.

Treatment plan. The patient was scheduled for coronary artery bypass surgery and a frozen elephant trunk procedure using the short stent-graft component as the primary entry tear was thereby covered. No CSF drainage was inserted as by the strategy chosen, the remaining risk of symptomatic spinal cord injury was deemed very low. The option for secondary TEVAR extension remains if aortic remodeling turns out to be insufficient. Total aortic arch rerouting was not favored as the combination of total aortic arch rerouting and TEVAR in patients with acute aortic syndromes (in addition with a large ascending aortic diameter) has a substantial risk for retrograde type A aortic dissection.

Case 7- Aortic arch penetrating atherosclerotic ulcer (PAU)

Clinical scenario. A 62-year-old male with prostate carcinoma underwent CTA for carcinoma staging. CTA shows a large PAU with diameters 25/30 mm in the distal aortic arch. The patient is asymptomatic and he has no history of previous aortic repair. There are no metastases of prostate carcinoma.

Additional examinations guiding the decision how to proceed. The patient undergoes a full cardiovascular workup including a new ECG triggered CTA starting cranially including the circle of Willis and extending below to the level of the femoral heads. Furthermore, coronary angiography

Constellations favoring transposition of supraaortic vessels and TEVAR. CTA shows PAU in the distal aortic arch at the lesser curvature at the level of the left subclavian artery at the transition from zone 2 to zone 3. The maximum diameter of the ascending aorta, aortic arch and descending aorta are 38, 35 and 32 mm, respectively. In TEE, the valvular status is normal and in the coronary angiography there is no significant coronary heart disease.

Treatment plan. Since revascularization of the LSA will provide a sufficient proximal landing zone of 28 mm, both LSA to LCCA bypass/ transposition and zone 2 TEVAR are recommended. In case of a too short distance between the LSA and the LCCA, double transposition and zone 1 TEVAR might be recommended. To minimize the risk of symptomatic spinal cord injury-graft (10-15 cm) is recommended. As the distal landing zone is in the proximal zone 4, CSF drainage might be omitted, if there are no large thoracic segmental artery offsprings at rthat level.

Constellations favoring branched arch endo-graft implantation. CTA shows that the distance between the brachiocephalic trunk and the LSA is short and that double transposition might provide a proximal landing zone of only 1.3 cm. The dimensions of the ascending aorta are regular showing a 37mm maximum diameter. There is a 50% stenosis of the left anterior descending coronary artery and the valvular status and left ventricular ejection fraction are normal. The patient is under cortisone for 18 years due to severe polyarthritis and the healing process after any skin incision is challenging. The anatomy of the aortic arch including supraaortic vessels is suitable for implantation of a double branched endo-graft. Access vessels show regular diameters for retrograde stent-graft delivery.

Treatment plan. The patient is recommended to undergo subclavian-to-carotid bypass on the left side and implantation of the double branched endo-graft via the femoral artery.

Constellations favoring open surgery using the FET technique. CTA shows that the maximal diameter of the ascending aorta is 49 mm and the patient has an aortic valve moderate stenosis and moderate insufficiency. The left ventricle is dilated. Furthermore, there is a severe coronary heart disease with significant stenosis in left and right coronary system. PAU is situated at the level of the left subclavian artery at the transition from zone 2 to zone 3.

Treatment plan. The patient is recommended to undergo total aortic arch replacement using the FET technique including replacement of the ascending aorta, biological aortic valve replacement and revascularization of the coronary arteries. The anastomosis of the FET prosthesis cuff (at the transition between the surgical prosthesis and stent-graft portion) can be performed proximal to the aortic arch PAU in zone 1 or 2 to ensure the circular aortic wall for the cuff-aortic wall anastomosis and to reduce the risk of recurrent nerve injury. The stent-graft portion length of FET prosthesis should be short in order reduce the remaining risk of spinal cord injury to a minimum.

Case 8- Graft infection involving the aortic arch

Clinical scenario. A 68- year old male presents with fever and elevated inflammatory parameters 4 months after aortic root replacement with a biological valve carrying conduit and after simultaneous ascending and hemiarch replacement due to aneurysmal formation. Due to diffuse bleeding during the index procedure, the sternum remained open and chest sponge tamponade was performed for 48 hours, afterwards, the sternum was closed and the remaining clinical course was uneventful. Standard antibiotic therapy according to the institutional protocol was applied.

Additional examinations guiding how to proceed. The patient undergoes a full cardiovascular workup including a new ECG triggered CTA starting cranially including the circle of Willis and extending below to the level of the femoral heads. As compared to the completion CT scan at discharge, air bubbles can be seen surrounding the prosthesis. At the level of the hemiarch anastomosis, a pseudoaneurysm can be seen. The neurocranium is free from detectable embolic events. A trans-thoracic echocardiogram shows vegetations on the biological valve. Blood cultures show a Staphylococcus aureus sepsis. Therefore and also because the coronary angiogram showed regular findings at the index procedure, repetition was omitted.

Constellations favoring a conservative approach. None, if the clinical conditions are good.

Treatment plan. The patient is recommended to undergo redo surgery with complete explantation of the alloplastic material, radical debridement and orthotopic reconstruction using a neoaortic root formed from a bovine xenopericardial tube and a biological prosthesis, ascending and hemiarch replacement using an additional neo-aortic xenopericardial tube-graft. Alternatively, a homograft for the aortic root can be used. Also, re-alloplastic reconstruction with the option of additional omental flap plasty can be considered but the remaining risk of reinfection then seems to be higher. In addition, life-long antibiotic therapy is warranted.

References

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